Savannah River Site
Solid Waste Management Department
Consolidated Incinerator Facility
Operator Training Program

HEALTH PHYSICS & AREA RADIATION MONITORING (U)

Study Guide

ZIOITX58

Revision 01

Training Manager / Date

Engineering / Date

Facility Manager / Date

FOR TRAINING USE ONLY

The uncontrolled information contained in these training materials is FOR TRAINING USE ONLY. In no way should it be interpreted that the material contained herein may be substituted for facility procedures. Where copies of procedures are given, they are intended as examples and information only, and the latest revision of the material in question should be obtained for actual use. If you have any questions, contact your supervisor.

REVISION LOG

REV.	AFFECTED SECTION(S)	SUMMARY OF CHANGE
01	All	New Issue

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

REFERENCES

1. 261-SOP-HM-01, *Health Physics and Radiation Protection*, DRAFT Rev.
2. 5Q1.7 Procedure 107A, *Model GA-6 Operation and Source Check*, Rev. 4
3. BPF 216839, *GA-6M Gamma Monitor*
4. BPF 216914, *PANALARM Wiring Diagram*
5. J-JX-H-0020, *Setpoint Index for Consolidated Incineration Facility*, Rev. 3
6. NMC Nuclear Instrumentation, *GA-6M Gamma Alarm System Manual*, 1990
7. WSRC-SA-17, Consolidated Incineration Facility Safety Analysis Report, DOE Approval Copy 12/95
8. W830359, Radiation Monitors Instrument Control Diagram, Rev. 8
9. W842421, Area Radiation Monitoring Loop Diagrams Sht. 1 Instruments, Rev. 3
10. W842422, Area Radiation Monitoring Loop Diagrams Sht. 2 Instruments, Rev. 3
11. W842423, Area Radiation Monitoring Loop Diagrams Sht. 3 Instruments, Rev. 3
12. W845662, Area Radiation Monitoring Loop Diagrams Sht. 4 Instruments, Rev. 3
13. W845663, Area Radiation Monitoring Loop Diagrams Sht. 5 Instruments, Rev. 3
14. W845699, Alarm & Rad Mon Panel 2405-B Annun. Schematic Sht. 1 Instruments, Rev. 2
15. W845737, Alarm & Rad Mon Panel 2405-B Annun. Schematic Sht. 2 Instruments, Rev. 2
16. W845738, Alarm & Rad Mon Panel 2405-B Annun. Schematic Sht. 3 Instruments, Rev. 2

LEARNING OBJECTIVES

TERMINAL OBJECTIVE

1.0 Without references, **EXPLAIN** the significance of the Area Radiation Monitoring System to Consolidated Incinerator Facility operations, including its importance to safety, and the impact on operations of a failure of the system.

ENABLING LEARNING OBJECTIVES

1.1 **STATE** the purpose of the Area Radiation Monitoring System.

1.2 Briefly **DESCRIBE** how the Area Radiation Monitoring System accomplishes its intended purpose.

1.3 **EXPLAIN** the consequences of a failure of the Area Radiation Monitoring System to fulfill its intended purpose, including the effects on other systems or components, overall plant operation, and safety.

TERMINAL OBJECTIVE

2.0 Using system diagrams, **EVALUATE** potential problems which could interfere with normal Area Radiation Monitoring System flow paths to determine their significance on overall system operation and the corrective actions needed to return the system to normal.

ENABLING LEARNING OBJECTIVES

2.1 **DESCRIBE** the physical layout of the Area Radiation Monitoring System components including the general location, how many there are, and functional relationship for each of the following major components:

a. Rad Monitoring Panel
b. Readout/Control Module
c. Local Alarm Panels
d. Scintillation Detectors

2.2 Given a description of abnormal equipment status for the Area Radiation Monitoring System, **EXPLAIN** the significance of the condition on system operation.

2.3 Given a description of the Area Radiation Monitoring System equipment status, **STATE** any corrective actions required to return system operation to a normal condition.

TERMINAL OBJECTIVE

3.0 Given values of Area Radiation Monitoring System operation parameters, **EVALUATE** potential problems that could effect the normal functioning of the system or its components to determine the significance of the existing condition and the actions required to return the system to normal operation.

ENABLING LEARNING OBJECTIVES

3.1 **DESCRIBE** the following major components of the Area Radiation Monitoring System including their functions, principles of operation, power supplies, and basic construction:

a. Rad Monitoring Panel
b. Readout/Control Module
c. Scintillation Detectors
d. Local Alarm Panels

3.2 Given values for key performance indicators, **DETERMINE** if Area Radiation Monitoring System components are functioning as expected.

3.3 **INTERPRET** the following Area Radiation Monitoring System alarms, including the conditions causing alarm actuation and the basis for the alarms:

a. High Radiation
b. Monitor Failure

3.4 **EXPLAIN** how the following Area Radiation Monitoring System equipment is controlled in all operating modes or conditions to include control locations (local or Control Room), basic operating principles of control devices, and the effects of each control on the component operation:

a. Rad Monitoring Panel
b. Readout/Control Module
c. Local Alarm Panels

3.5 **DESCRIBE** the interlock associated with the Control Room Radiation Monitor to include the interlock actuating conditions, effects of interlock actuation, and the reason the interlock is necessary.

TERMINAL OBJECTIVE

4.0 Given necessary procedures or other technical documents and system conditions, **DETERMINE** the operator actions required for normal and abnormal operation of the Area Radiation Monitoring System including problem recognition and resolution.

ENABLING LEARNING OBJECTIVES

4.1 **STATE** the personnel safety concerns associated with the Area Radiation Monitoring System.

4.2 Given applicable procedures and plant conditions, **DETERMINE** the actions necessary to perform the following Area Radiation Monitoring System operations:

a. Startup
b. Shutdown

4.3 **DETERMINE** the effects on the Area Radiation Monitoring System and the integrated plant response when given any of the following:

a. Indications/alarms
b. Malfunctions/failure of components
c. Operator Actions

SYSTEM OVERVIEW

ELO 4.1	**STATE the personnel safety concerns associated with the Area Radiation Monitoring System.**

Safety

Normal operation of the Health Physics & Area Radiation Monitoring (HM) System presents limited safety hazards for operators. As with any electrical system, the potential for dangerous voltage exists when electrical leads or panels are open or exposed. Follow the safety practices as required in Manual 8Q, Employee Safety Manual.

Introduction

The Consolidated Incineration Facility (CIF) processes hazardous materials containing radionuclides. Because of the storage and handling of these radionuclides, operators are presented with the possibility of being exposure to gamma radiation. The ALARA concept of keeping exposure to a minimum is applicable in the CIF. The HM System is designed to minimize radiation exposure to the operator by detecting higher than normal radiation levels and alerting operators by the use of instrumentation and alarms.

SYSTEM PURPOSE

ELO 1.1	STATE the purpose of the Area Radiation Monitoring System.

System Purpose

The purpose of the Health Physics & Area Radiation Monitoring System is to monitor the CIF at strategic locations for gamma radiation. If the detected level of radiation exceeds the high set-point, audible and visual alarms will indicate the location of the radiation and a remote meter indication will display the level of radiation.

The Area Radiation Monitoring System assists facility operators in maintaining their exposure As Low As Reasonably Achievable (ALARA). By monitoring levels at the detectors, and maintaining awareness of the areas with higher radiation levels, the operator can work to minimize exposure from these areas.

DESCRIPTION AND FLOWPATH

ELO 1.2	**Briefly DESCRIBE how the Area Radiation Monitoring System accomplishes its intended purpose.**
ELO 2.1	**DESCRIBE the physical layout of the Area Radiation Monitoring System components including the general location, how many there are, and functional relationship for each of the following major components:** **a. Rad Monitoring Panel** **b. Readout/Control Module** **c. Local Alarm Panels** **d. Scintillation Detectors**

The Health Physics & Area Radiation Monitors (ARMs) are gamma radiation detection devices. The system currently has a total of thirteen (13) loops. Each loop consists of a:

- Scintillation Detector
- Local Alarm Panel
- Readout/Control Module

The thirteen loops are located throughout the facility for detection of radiation levels from expected sources. There is currently a design change expected which will remove ten (10) of the detectors from service and reposition the remaining three (3) detectors at the most strategic locations for high radiation detection. The detectors to be relocated are the Box Handling X-ray detector (H-261-HM-RE-5202), the Tank Farm detector (H-262-HM-RE-5203), and the Ashcrete Processing detector (H-261-HM-RE-5207). The first detector will be moved to the

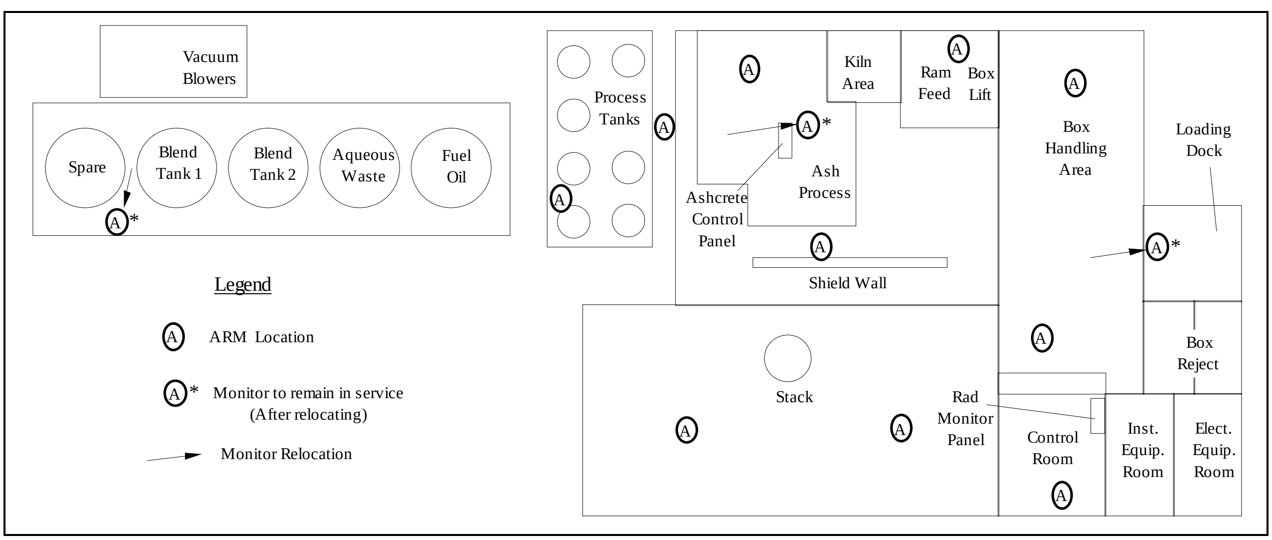


Figure 1 ARM Detector Locations

conveyor entrance from the Loading Dock to the Box Handling Area. It will be used to detect high radiation levels from solid waste containers entering the facility. The second detector will be repositioned to better measure radiation levels from either Blend Tank 1 or the Spare Tank. It will also be able to measure radiation levels from Blend Tank 2, but not as completely as the other two tanks because of its distance. The third detector will be repositioned closer to the Ashcrete Processing Station in order to detect a buildup of radioactive contamination in either the ash receiving tank, the ash processing unit, or the drum which is receiving waste from the ashout chute. See Figure 1, *ARM Detector Locations*, for more detail.

Each loop contains a detector probe, a local alarm panel, and a readout/control module. The readout/control module houses the millirem per hour (mR/hr) meter. Local alarm panels in the field consist of an audible alarm horn, acknowledge and test switch, and beacon alarm lights above the local alarm panel. Red beacons indicate high gamma readings. The detector housing, consisting of a stainless steel sleeve with a scintillation crystal, photo multiplier tube, and associated circuitry, is located in proximity to its associated local panel. System components and controls are listed in Table 1, *W830359 Designations*, below. CLI numbers are written with 52XX indicating the numbers 5200 through 5212. See Figure 2, *Excerpt from W830359*, for a diagram of detector arrangement and designations.

(EN) Drawing Designation	CLI	Name
*A	H-261-HM-ANN-52XX-(D)	Audible Horn
*B	H-261-HM-PNL-52XX	Local Alarm Panel
*PB-1	H-261-HM-HS-52XX-(A)	Acknowledge Push-Button
*PB-2	H-261-HM-HS-52XX-(B)	Test Push-Button
*RSH	H-261-HM-RSH-52XX	High Radiation Switch
*X	H-261-HM-RE-52XX	Radiation Detector
*XA	H-261-HM-ANN-52XX-(C)	Flashing Light
*XA-1	H-261-HM-RAH-52XX-(B)	High Radiation Alarm (2405)
*XA-2	H-261-HM-RAH-52XX-(A)	High Radiation Alarm (DCS)
*XA-3	H-261-HM-YA-52XX-(B)	Monitor Failure Alarm (2405)
*XA-4	H-261-HM-YA-52XX-(A)	Monitor Failure Alarm (DCS)
*XA-5	H-261-HM-RAH-52XX-(E)	Local Alarm Light
*XG	H-261-HM-RI-52XX	DCS Radiation Indication
*XT	H-261-HM-RIT-52XX	Readout/Control Module
*YS	H-261-HM-YS-52XX	Monitor Failure Switch

Table 1 W830359 Designations

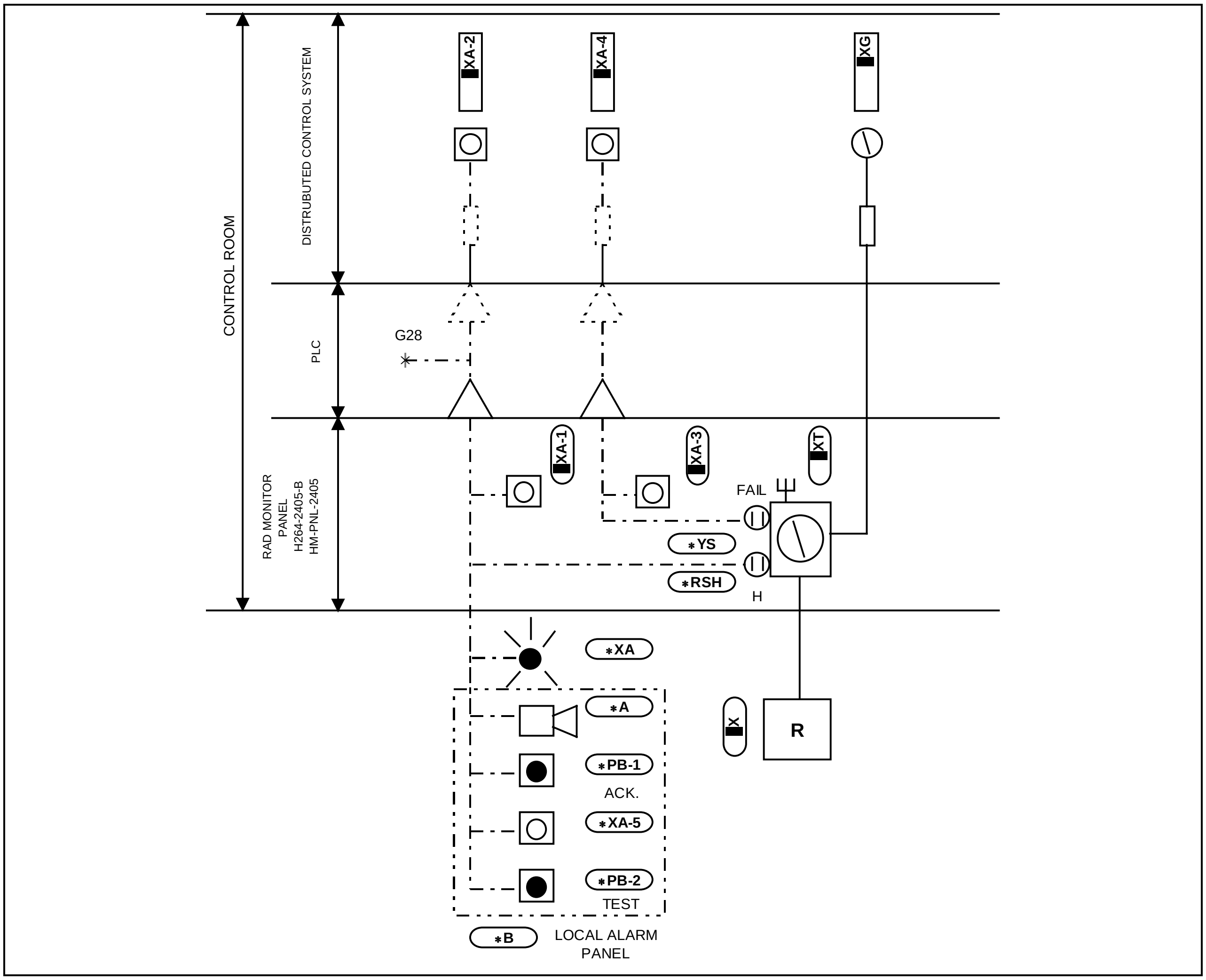


Figure 2 Excerpt from W830359

Flow-path of Area Radiation Monitoring System

When the gamma radiation detectors receive gamma radiation, the scintillation crystal converts the energy from the radiation to light waves, and the light waves are amplified and converted to electrical energy. The electrical energy is sent to the meters located on the Rad Monitoring Panel in the Control Room, where they are again amplified and displayed. When the displayed electrical energy exceeds the set-point, it will cause an alarm. This alarm for high radiation is indicated on the local alarm panel, the Rad Monitoring Panel in the Control Room, and DCS.

The Rad Monitoring Panel (H-261-HM-PNL-2405) in the Instrument Control Room (ICR) contains thirteen (13) readout/control modules. All modules have alarm annunciators corresponding to the local area detectors. Each detector feeds information to its respective readout/control module. DCS receives signals from the modules for monitoring capabilities as well as for archiving data.

MAJOR COMPONENTS

ELO 3.1	**DESCRIBE the following major components of the Area Radiation Monitoring System including their functions, principles of operation, power supplies, and basic construction:** **a. Rad Monitoring Panel** **b. Readout/Control Module** **c. Scintillation Detectors** **d. Local Alarm Panels**

Rad Monitoring Panel

The Rad Monitoring Panel (H-261-HM-PNL-2405) is a common alarm and indication panel for several systems. The Breathing Air, Fire Protection/Fire Detection and Alarm System, Air Monitoring System, and Area Radiation Monitoring System all have indications or alarms on the Rad Monitoring Panel. The indications and alarms on the Rad Monitoring Panel are powered from the UPS. These alarms and indications are processed by the Rad Monitoring Panel as relay contacts or meter indications before a complimentary signal (generated by auxiliary contacts) is sent to DCS.

Since it does not rely upon DCS support or processing, these signals would still alarm or indicate on the Rad Monitoring Panel. For this reason, the Rad Monitoring Panel handles critical alarms and indications. The Rad Monitoring Panel has also been referred to as the “Critical Annunciator Panel” because of the alarms which it displays.

Readout/Control Module

The readout/control modules (Figure 6) provide 27 VDC power to the gamma detector, accept signals from the detectors, amplify the signals, and determine alarm conditions. Signals from the control modules activate alarms on the Rad Monitoring Panel, DCS, and the local alarm panels. Radiation level signals are also sent to DCS for data storage and archiving purposes.

The modules are provided with alarm test switches and the instrumentation to calibrate the detector and controls. See the Instrumentation chapter for more information on the readout/control modules.

Scintillation Detector

The gamma radiation detectors are gamma scintillation detectors which utilize a 2" diameter plastic scintillator optically coupled to a photo multiplier tube. A scintillator is a crystal which emits a flash of light when exposed to radiation. A stainless steel sleeve protects the crystal, photo multiplier tube, and associated circuitry. The photo multiplier tube is a device which electrically and physically amplifies the light waves emitted by the scintillator. The light is then sent to a photo detector (photocathode) which transforms the light energy into electrical energy in the form of electrons in a vacuum tube. The electrons are then amplified by a series of dynodes in the photomultiplier tube. The final amplified electron signal is registered as a current pulse which is proportional to the energy and magnitude of the light emitted from the gamma interaction. Each detector transmits signals to its associated readout module where the value of the signal is converted to a mR/hr readout and signal. Each detector contains an integral light emitting diode (LED) which provides an "Artificial Background" signal and provides a means for upscale testing of the unit.

The detector has several unique features which are important for use at CIF. If a high radiation field occurs, the instrument has the capability of pegging at full scale, but will not jam or become saturated. It will return to normal readings when the field subsides to a readable level. The instrument is also designed to screen out stray electrostatic and electromagnetic fields that might be generated by motors and engines.

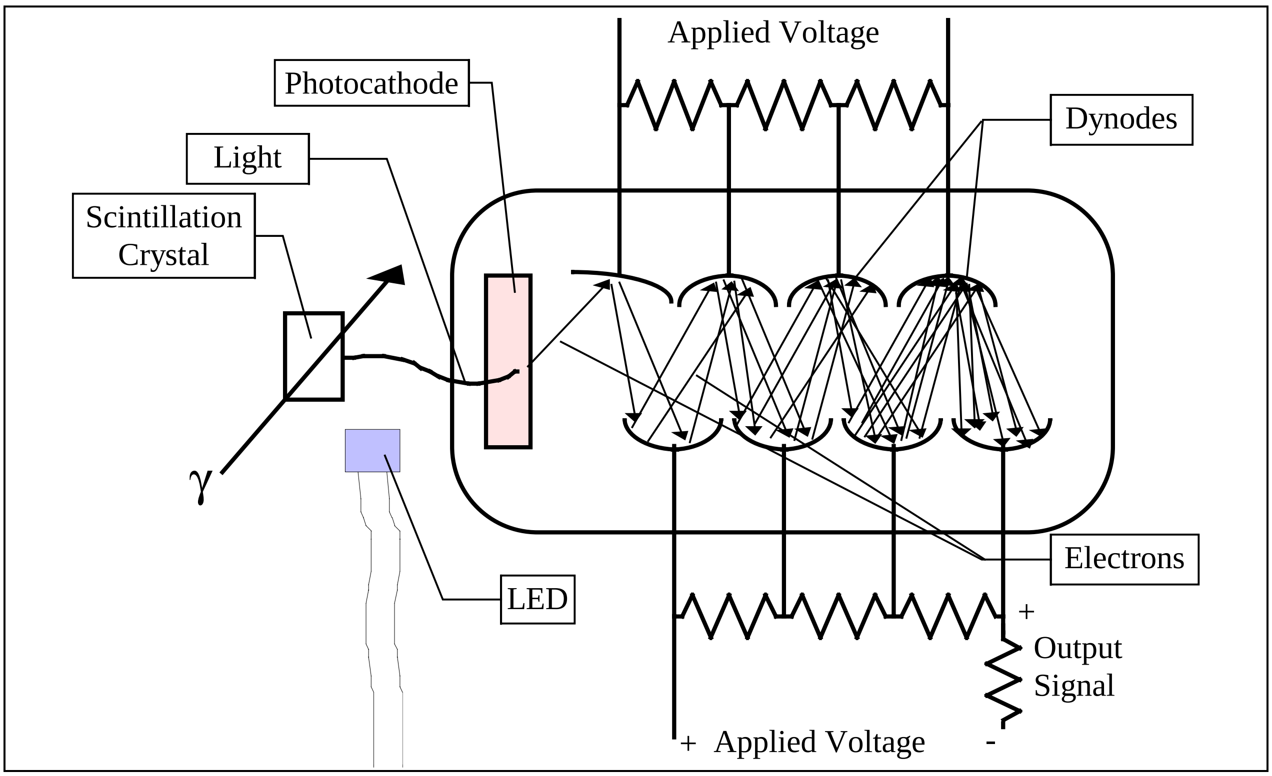


Figure 3 Scintillation Detector

Scintillation detectors are used because of their efficiency and high precision and counting rates that are possible. The light generated by an interaction with a particle is very brief, which allows a high sensitivity to low radiation levels. The intensity of the light and the resulting output voltage of the detector is also proportional to the energy of the particle responsible for the flash. This makes a scintillation detector useful in evaluating the number as well as the energy of the particles.

Local Alarm Panel

Local alarm panels, located in the thirteen monitored areas, consist of alarm circuitry, an audible alarm horn, acknowledge and test switch, and beacon alarm lights above the local alarm panel. Each area radiation detector and its local alarm panel are located within close proximity to each other. The acknowledge and test switch is designated as two push-buttons on Drawing W830359 (Figure 2, *Excerpt from W830359*) but actually consist of a single three (3) position center off momentary switch. (See Figure 4, *Local Alarm Panel.*)

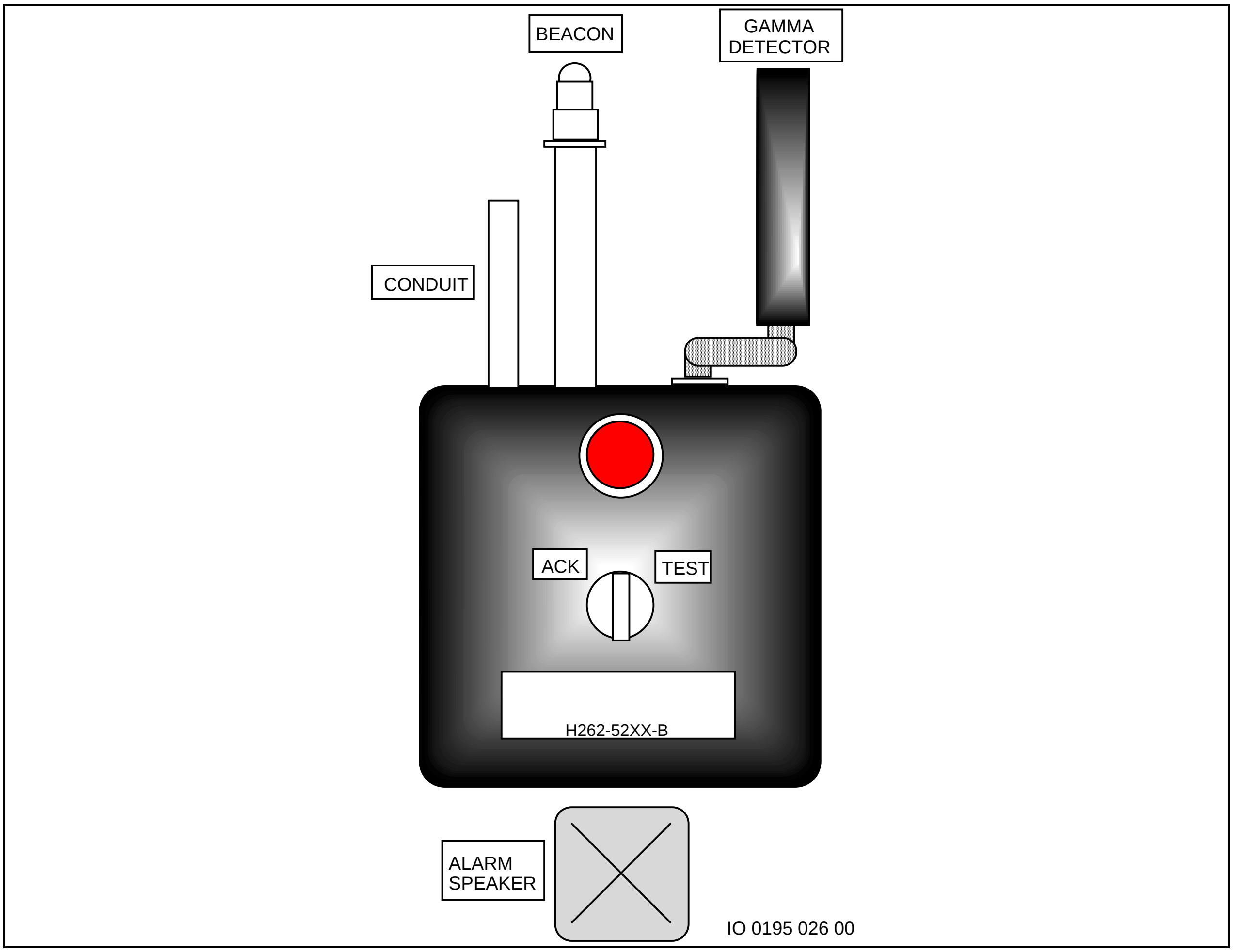


Figure 4 Local Alarm Panel

Power Supplies

The Uninteruptable Power Supply (UPS) supplies 120 VAC to the Instrument Power panels. The UPS is operated according to 261-SOP-UPS-01 as a prerequisite for ARMs start-up. A 120 VAC power supply from Power Panel 'E' supplies the readout/control modules. The readout/control modules contain voltage transformers which convert the 120 VAC signal to 27 VDC and 14 VDC. The 27 VDC supplies power to the detector probe.

The loop systems have three power sources, but only one power supply is hardwired to the readout/control module. This power originates from Instrument Power Panel 'E'. The second power supply drives the alarm relays on the Rad Monitoring Panel and the local alarm panel. This power originates from different Instrument Power Panels, typically from the panel nearest to the local alarm panel. The third power supply provides an instrument failure alarm. This power supply is common to all the radiation monitors located in the Rad Monitoring Panel and supplies relays other than the Area Radiation Monitoring system. This power originates from Instrument Power Panel 'E'. In the event of a loss of power from Instrument Power Panel 'E' to the Rad Monitoring Panel, there will be no monitor failure alarms since this alarm requires a power supply to activate. See Figure 5, *Power Supplies*, for details of typical alarm and monitoring power supplies.

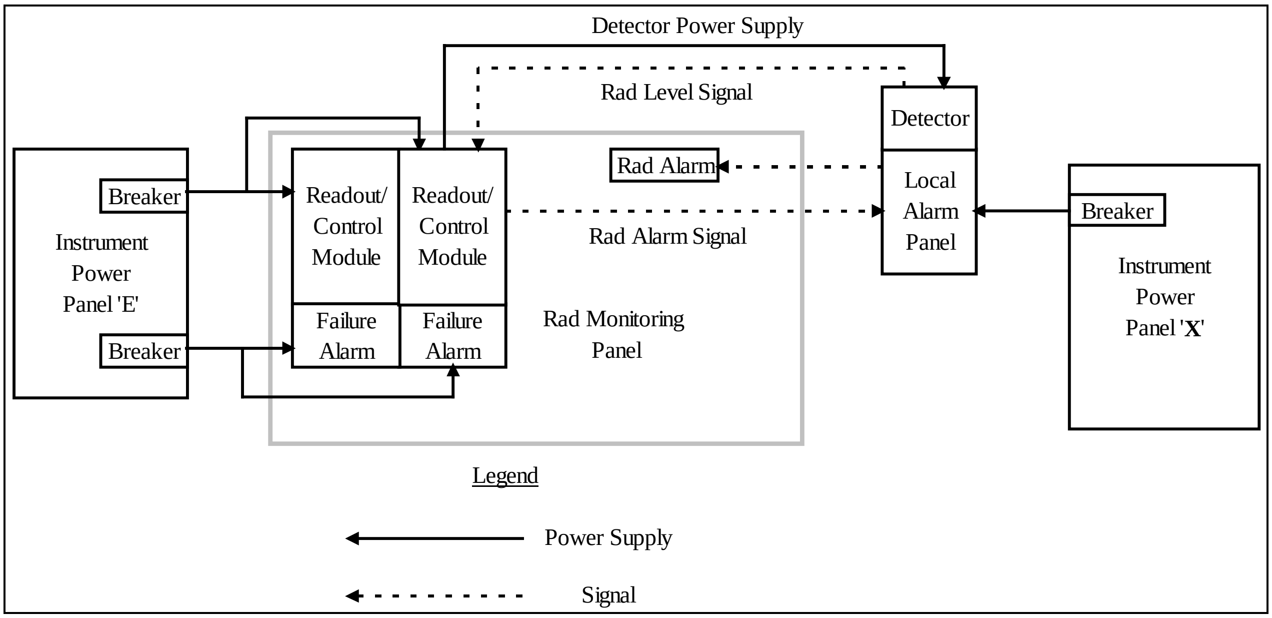


Figure 5 Power Supplies

INSTRUMENTATION

ELO 3.2	Given values for key performance indicators, DETERMINE if Area Radiation Monitoring System components are functioning as expected.

Rad Monitoring Panel

The Rad Monitoring Panel contains meter indications for individual detectors (AM and HM System), strip chart recorders, control buttons, and the alarm annunciator panel. The alarm annunciator panel is a ten (10) column by five (5) row matrix of alarm cards. Each card has three (3) alarm annunciators available for a total of one hundred fifty (150) annunciators available. There are control buttons and indications for Air Monitoring System vacuum blowers, test and alarm acknowledge buttons for the panel, and automatic emergency shut down push-buttons for the incinerator. The strip chart recorders display incinerator and waste feed parameters such as Rotary Kiln (RK) Pressure, Secondary Combustion Chamber (SCC) and RK temperature, carbon monoxide emissions, offgas flow, and waste feed flow rates. A push button for automatic shutdown is also located on the Rad Monitoring Panel.

The Rad Monitoring Panel is designed as a stand alone panel which will be available for indication and alarms in the event of a malfunction of the DCS. Alarm signals for the Rad Monitoring Panel are fed directly into the panel, and any indication which the DCS receives comes after the Rad Monitoring Panel has processed its signals and alarms.

Readout/Control Module

The readout/control module front panel is equipped with several controls/indicators:

- The meter provides a full scale reading of 0.1 to 1000 mR/hr of its associated gamma detector. This meter is a logarithmic indication.
- A white power indicator lamp is illuminated when electrical power is energizing the module.
- A red high alarm lamp illuminates when the gamma activity exceeds the alarm set-point, indicating a high gamma radiation field in the area of the Detector. The high alarm set-point is displayed by depressing the red "ALARM" push-button on the meter.
- An amber detector fail lamp illuminates when the gamma activity falls below a preset activity level, indicating detector failure. The fail alarm set-point is displayed when the yellow "FAIL" push-button is depressed.
- An "L-T" (Lamp Test) toggle switch is used to verify that the “FAIL” and “ALARM” lamps are working and are not defective or burned out.
- The white "U-C" (Upscale Check) push-button initiates an upscale detector check.

- The normal operating position of the "TEST-OP" toggle switch is "OP." When toggled to the “TEST" position, this switch tests the high alarm circuitry by driving the meter upscale past the high alarm set-point.
- The "AB/OFF" control switch is used to select the status of the LED. The normal operating position is "AB" (Artificial Background). With the Artificial Background (AB) switches in "AB" position, the LED in each ARM provides a background internal light level sufficient to provide the photo electric detector with a minimum signal. This minimum signal will in turn indicate a minimum reading on the meter. If the meter fails, or the switch is placed in the "OFF" position, the LED will be extinguished. With no signal generated, the "FAIL" alarm will be indicated.

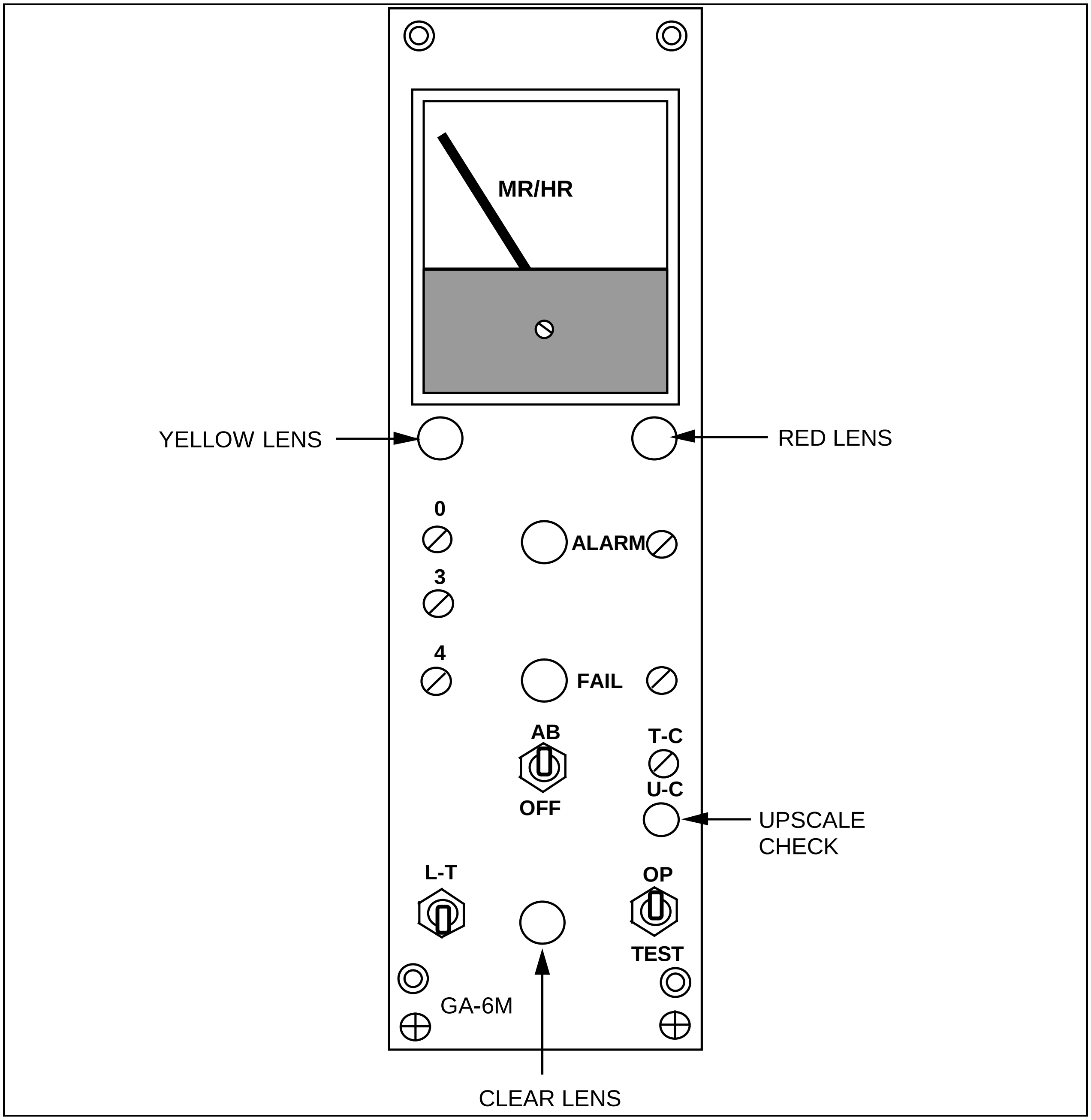


Figure 6 Readout/Control Module

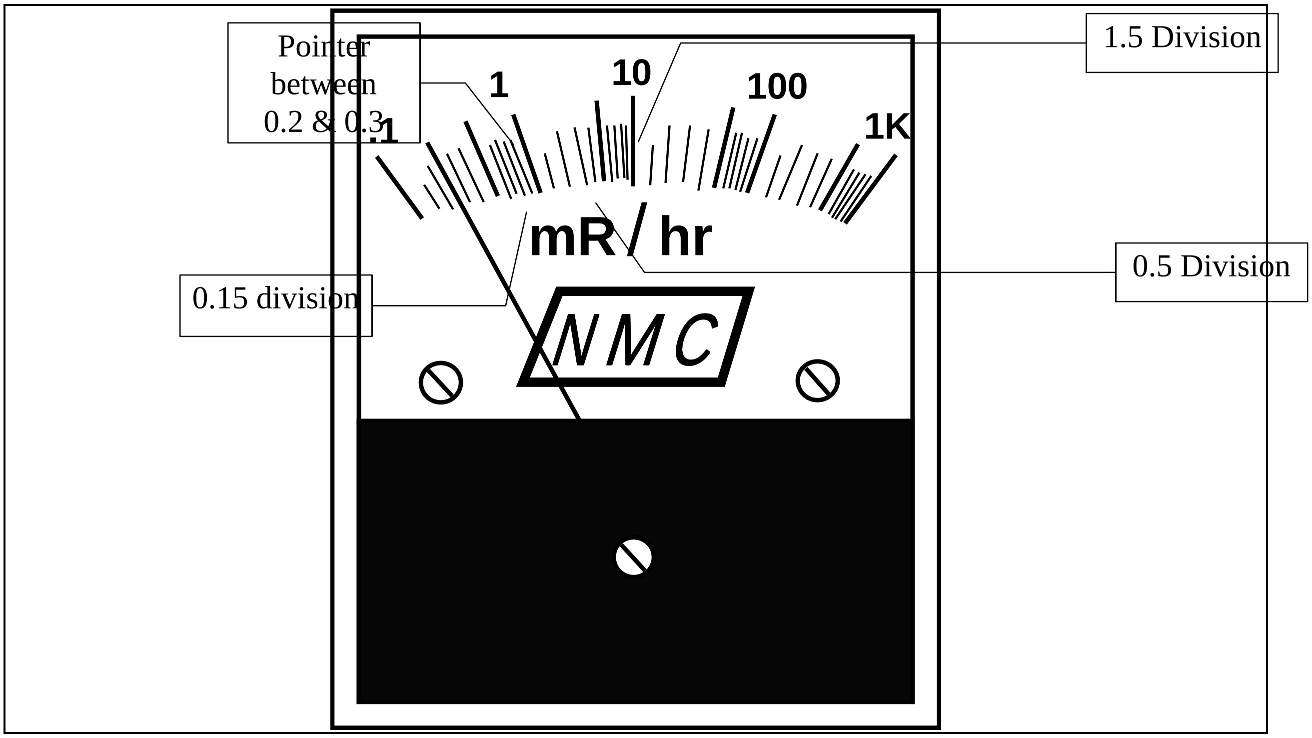
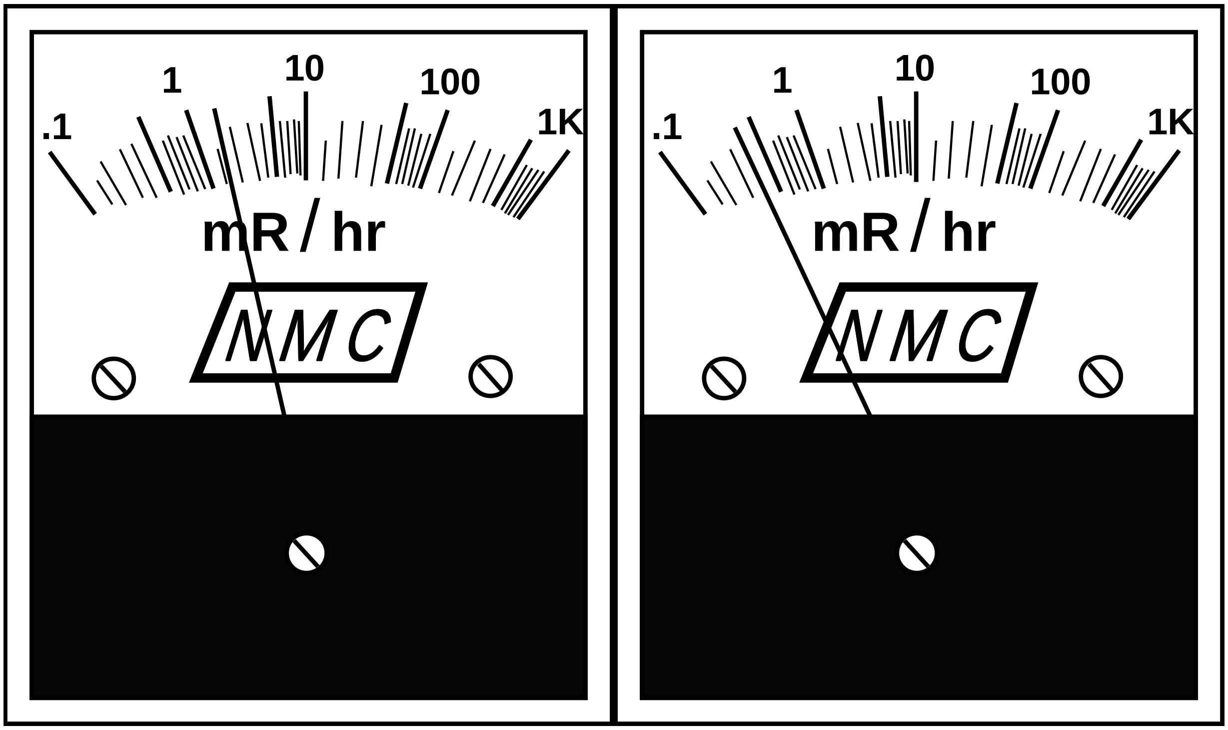


Figure 7 Meter Detail

As stated previously, the meter is in a logarithmic scale. As indicated in Figure 7, *Meter Detail*, the pointer is in the position which indicates between 0.2 mR/hr and 0.3 mR/hr. This meter is confusing because instead of dividing the scale into ten points, it adds a point between the 1 and 2 digit for the 1.5 digit. This leads to the division into eleven points. There are several ways to prevent mistakenly reading the meter. One way is to recognize that the first division is of a shorter length than the others, thus indicating a lesser value (0.15). Another way is to look for the 5th division, which is the darker/thicker line between the factor of 10s divisions. (The 0.5 division is noted in Figure 7.) From the 5th division, you can count back to see in the indicated figure that the pointer is indeed between the 2nd and 3rd full length divisions.

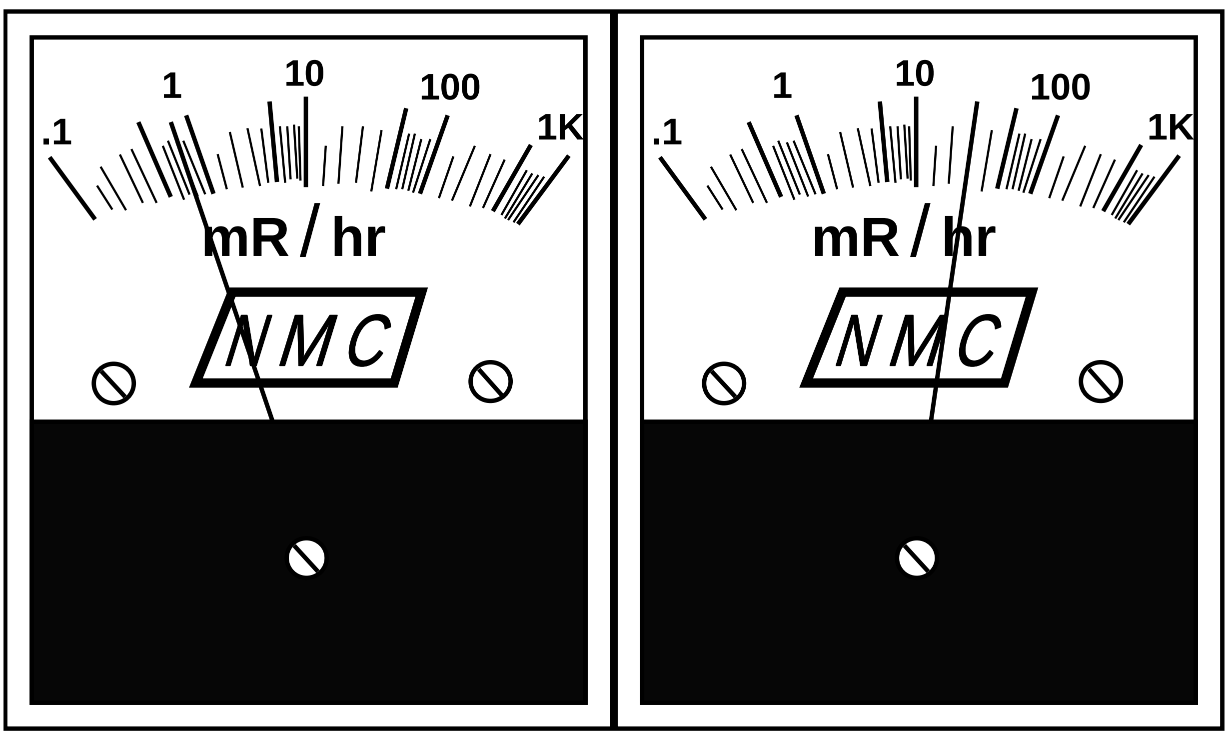
Review

- See Figures 8 and 9 for meter indications. What do each of the meters read?



Meter A Meter B

Figure 8 Example 1 of Meter Indications



Meter C Meter D

Figure 9 Example 2 of Meter Indications

CONTROLS, INTERLOCKS AND ALARMS

ELO 3.4	**EXPLAIN how the following Area Radiation Monitoring System equipment is controlled in all operating modes or conditions to include control locations (local or Control Room), basic operating principles of control devices, and the effects of each control on the component operation:** **a. Rad Monitoring Panel** **b. Readout/Control Module** **c. Local Alarm Panels**

Controls

Controls for alarms and alarm acknowledgment are located on the front of the Rad Monitoring Panel, readout/control modules, and local alarm panels. The only control function expected to be used by operators would be the acknowledgment of alarms. However, Maintenance personnel may require assistance from operators during testing or surveillances. Knowledge of switch and control functions, therefore, may be invaluable to assist with the performance of these operations.

Rad Monitoring Panel

The alarm acknowledge and test push-buttons are located on the front of the Rad Monitoring Panel to the left of the center. They are between the alarm panel lights and the Continuous Air Monitoring count rate meters. The acknowledge push-button is on the right as you face the panel. (See Figure 10, *Rad Monitoring Panel*.)

Depressing the "TEST" push-button will cause a contact to close which will illuminate the lights on the alarm annunciator panel. This can be used to determine if any lights are burned out on the panel.

When an alarm is received on the alarm annunciator panel, a horn will sound and the affected cell will flash to indicate the alarming condition. To silence the horn, the "ACK" push-button is depressed. When the alarm is acknowledged, the flashing indication will become a steady illuminated cell, and the horn will silence.

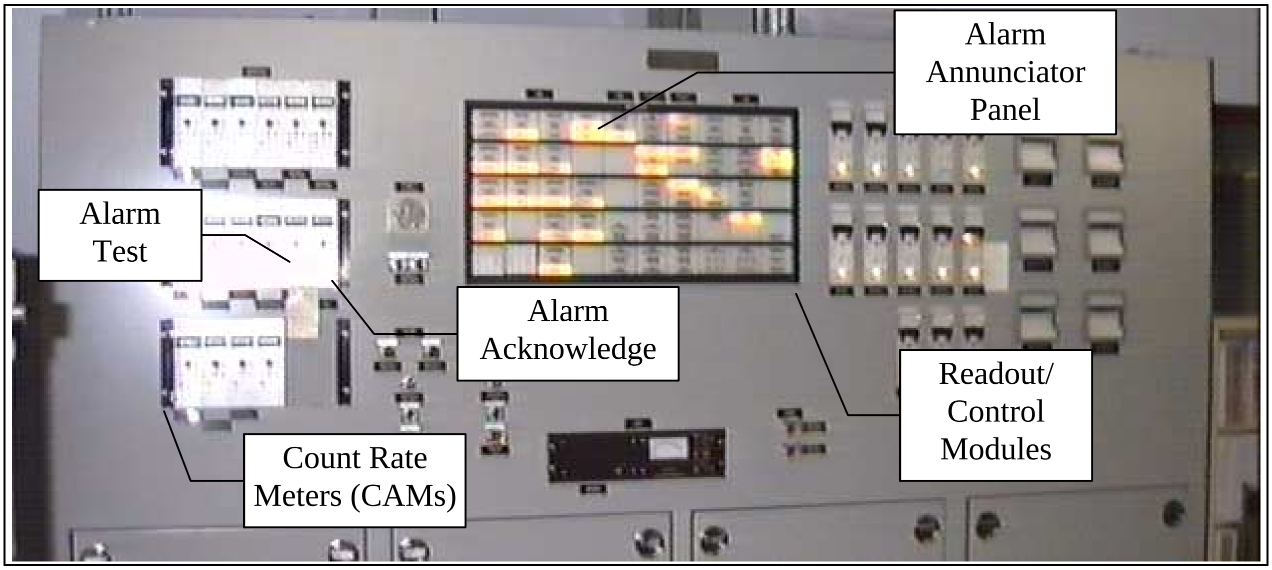


Figure 10 Rad Monitoring Panel

Readout/Control Modules

The readout/control modules provide the interface and instrumentation to calibrate the LED detector and controls. Calibration is performed by Maintenance as directed by Health Physics.

The normal operating position of the "TEST-OP" toggle switch is "OP," and the switch is spring return to the “OP” position. When toggled to the “TEST" position, this switch tests the high alarm circuitry by driving the meter upscale past the high alarm set-point.

An "L-T" (Lamp Test) toggle switch is used to verify that the “FAIL” and “ALARM” lamps are working and are not defective or burned out. This switch has a spring return to the non-active position.

The white "U-C" (Upscale Check) push-button is similar to the “TEST-OP” switch. It initiates an upscale detector check, but does not initiate an alarm as the meter is driven higher.

The "AB/OFF" control switch is used to select the status of the LED internal to the detector. The normal operating position is "AB" (Artificial Background). With the Artificial Background (AB) switches in "AB" position, the LED in each ARM provides a background internal light level sufficient to provide the photo electric detector with a minimum signal. This minimum signal will in turn indicate a minimum reading on the meter. If the meter fails, or the switch is placed in the "OFF" position, the LED will no longer be illuminated. With no signal generated, the "FAIL" alarm will be indicated. The normal operating position of the "AB/OFF" control switch is "AB".

Local Alarm Panels

As shown in Figure 4, *Local Alarm Panel*, the detector has a local indication of power available, high radiation alarm condition, and is provided with controls to test and acknowledge the high radiation signal. The control switch on the local alarm panel is a three (3) position center-off momentary switch. A simplified schematic of internal control relays for the local alarm panels is shown in Figure 11, *PANALARM Relay Circuitry*. The sequence of relay energization and functions is given in Table 2, *PANALARM Operational Sequence.*

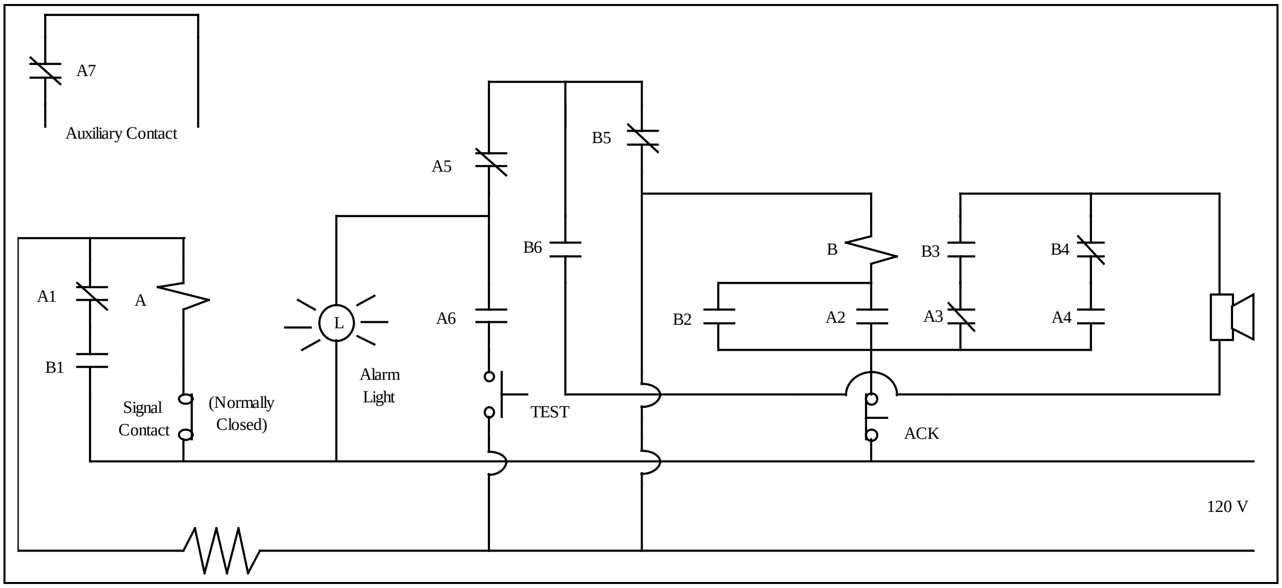


Figure 11 PANALARM Relay Circuitry

Condition	Signal Contact	Signal Lamp	Audible Signal	'A' Relay	'B' Relay
Normal	Closed	Off	Off	Energized	Energized
Alarm	Open	Steady-On	On	Deenergized	Energized
Acknowledge	Open	Steady-On	Off	Deenergized	Deenergized
Normal Again	Closed	Off	Off	Energized	Energized
Lamp Test	Closed	Steady-On	Off	Energized	Energized

Table 2 PANALARM Operational Sequence

An alarm condition opens the normally closed signal contact, which deenergizes the 'A' relay. Rotating the switch to the "ACK" position breaks contact in the alarm circuitry to deenegize the 'B' relay when locked in by an alarm. The A1 and B1 contacts provide a "signal lock" which maintains the 'A' relay deenergized until the alarm has been acknowledged. Rotating the switch to the "TEST" position causes contact to be made in the circuitry through to provide current through contact A6 to the alarm light (and beacon light not shown) which will verify their operability.

ELO 3.5	**DESCRIBE the interlock associated with the Control Room Radiation Monitor to include the interlock actuating conditions, effects of interlock actuation, and the reason the interlock is necessary.**

Interlocks

The Area Radiation Monitor System has one interlock. This interlock is provided from the detector in the Control Room (H-261-HM-RE-5204). This interlock works with the combustive gas detector so that a high alarm on either secures the toilet exhaust fan in the Control Room. The designed purpose for this interlock was to prevent the exhaust fan from either drawing the atmosphere into the Control Room or expelling the atmosphere from the Control Room. Due to the Control Room being maintained at a positive pressure with respect to the remainder of the facility, drawing the atmosphere into the Control Room is not likely. The probability that the Control Room is the location of the source of the high radiation alarm is also unlikely since the level of contamination required to cause a high radiation condition is so high that it is improbable. To have this same level of airborne contamination originating inside the Control Room would require that a high level source was inside the Control Room, and that source was leaking. As part of the planned changes to the Area Radiation Monitoring System, this interlock will likely be removed.

ELO 3.3	**INTERPRET the following Area Radiation Monitoring System alarms, including the conditions causing alarm actuation and the basis for the alarms:** **a. High Radiation** **b. Monitor Failure**

Alarms

Each meter has a range of 0.1 mR/hr to 1000 mR/hr. Health Physics will evaluate expected source strengths and update operators on expected normal levels.

The yellow detector fail lamp illuminates when the gamma activity falls below 0.20 mR/hr activity level, indicating detector failure. This loss of signal is transmitted as a monitor failure alarm.

The High Alarm set-point will be determined by Health Physics. An estimated setpoint of 2.0 to 3.0 mR/hr is reasonably expected since this setpoint will be above the background source but will alarm if levels increase much beyond background. This value was obtained from Manual 5Q1.7 Procedure 107A, *Model GA-6 Operation and Source Check*, Rev. 4, step 5.6.17.b, which lists typical alarm setpoints. See Table 3, *Typical Alarm Setpoints*, for additional setpoints. As operations continue and more experience and data is accumulated and evaluated, the setpoints will be adjusted to assist operators with maintaining their exposure within ALARA standards.

Background	**Alarm Setting**
0-5 mR/hr	2 mR/hr above background
6-10 mR/hr	3 mR/hr above background
11-20 mR/hr	4 mR/hr above background
20 mR/hr and greater	Set 20% above background

Table 3 Typical Alarm Setpoints

Example

- Calculate the expected setpoint for an Area Radiation Monitoring System detector at the Tank Farm if the background radiation is 12 mR/hr.
- What would the alarm setpoint be if the background were 20 mR/hr?
- What would the alarm setpoint be if the background were 36 mR/hr?

From Table 2, the alarm setting for a background value between 11 and 20 mR/hr is 4 mR/hr above the background. Therefore, for 12 mR/hr, the alarm would be expected to be 4 mR/hr above that or 12 + 4 = 16 mR/hr.

For 20 mR/hr, the alarm setpoint could be either 4 mR/hr above background or 20% above background since 20 mR/hr falls in both of the last rows of Table 2. If we use 4 mR/hr above background, the alarm setpoint is 20 + 4 = 24 mR/hr. If we calculate it using 20% above background we get: 20 times 20% = 4

20 + 4 = 24 mR/hr. (The same answer as above.)

The alarm setpoint for 36 mR/hr background would be: 36 times 20% = 7.2

36 + 7.2 = 43.2 mR/hr

SYSTEM INTERRELATIONS

Air Monitoring System

The count rate meters for the Continuous Air Monitors (CAMs) are located in the Rad Monitoring Panel, and activate alarms and indications on the Rad Monitoring Panel. The remote switches and indication for control of the CAM vacuum blowers as well as flow and temperature alarms are also located on the Rad Monitoring Panel.

Fire Protection/Fire Detection and Alarm System

Auxiliary relays in the Fire Alarm Control Panels activate alarms and indications on the Rad Monitoring Panel. The alarm relays activate contacts which send signals to the DCS.

Breathing Air System

The Breathing Air System sends signals to the Rad Monitoring Panel. These signals activate alarms on the alarm annunciator panel. The alarm relays activate contacts which send signals to the DCS.

Electrical Distribution System

The Rad Monitoring Panel and the equipment contained in the panel, and all the local alarm panels are powered from Instrument Power Panels. These power panels receive their supply from the UPS.

Distributed Control System

Alarms sent to the Rad Monitoring Panel are also transferred to the DCS through the use of “complimentary signals.” As an alarm relay is energized in the Rad Monitoring Panel, its contacts close to complete circuitry for indications and controls in the panel. Other contacts driven by that relay also close to send the same signal to DCS, hence the term “complimentary.”

INTEGRATED PLANT OPERATIONS

ELO 4.2	**Given applicable procedures and plant conditions, DETERMINE the actions necessary to perform the following Area Radiation Monitoring System operations:** **a. Startup** **b. Shutdown**

Normal Operations

Routine operations should not require any changes to HM System status. In the event that the system has been shut down, operators will be required to perform system alignments and system startup procedures.

System Alignments

The electrical power sources for the detector and the readout/control modules are energized before the local alarm panels are placed in service. After verifying that the electrical power sources are energized, the units are allowed to warm up for one hour. This step is necessary to prevent false or erratic indications on the system due to changes in resistivity of solid state components when warmed to operating temperatures.

The power for the readout/control modules is fed into the Rad Monitoring Panel to the detectors from Instrument Power Panel ‘E’. During system modification, the power supplies will likely be switched to include the three remaining detector power supplies on a single breaker.

Each ARM is "upscale checked" by pushing the "U C" push-button to test the high radiation alarm. When performing this upscale check, the individual ARM will alarm and then reset when the push-button is released.

System Startup

After pre-startup system alignments are completed, the system start-up is performed.

Each artificial background (AB) switch is turned to the "AB" position for each ARM. This turns on an LED which provides a background reading to make the meter read slightly above zero. This prevents false failure alarms. The amber "FAIL" indicating lights should extinguish as each artificial background switch is turned to the "AB" position.

Normal Operation

Routine observations of the readout/control module include observing:

- the amber lamp, which if illuminated, indicates a detector failure in the respective area.
- the red lamp, which if illuminated, indicates a high gamma radiation condition in the respective area.
- the white lamp, which should be illuminated, indicates the module is energized by electrical power.
- the meter indication, which will display the radiation level at the detector, or if failed, will indicate low (less than 0.2 mR/hr).

System Shut-down

The activity and radiation monitoring systems in the CIF will be the last systems to be shut-down if the facility is secured. The Area Radiation Monitoring System will be shut down by de-energizing the electrical power supplies feeding the detector and readout/control modules.

ELO 3.2	**Given values for key performance indicators, DETERMINE if Area Radiation Monitoring System components are functioning as expected.**
ELO 4.3	**DETERMINE the effects on the Area Radiation Monitoring System and the integrated plant response when given any of the following:** **a. Indications/alarms** **b. Malfunctions/failure of components** **c. Operator Actions**

Infrequent Operations

Infrequent operations include source checks and Maintenance checks on the system.

Routine activities associated with checks include:

- Positioning the "L-T" (Lamp Test) toggle switch "Test";
- Verifying the "low set-point" by depressing the yellow "fail" push-button;
- Initiating an "up-scale" detector check by depressing the "U-C" (Up-Scale Check) push-button;
- Testing the high alarm circuitry by changing the position of the "TEST-OP" toggle switch from "OP" to "TEST" and returning the switch to "OP."

Source Checks

Weekly source checks of radiation detectors will be performed by Radiological Control Operations (RCO) personnel. The source checks consist of positioning a known radiation source at different distances from the detector and observing for proper operation and response from the readout/control module. As part of the system response checks, alarms are expected when sufficient source strength is moved to the vicinity of the detector.

Maintenance Checks

Maintenance checks on the system will consist of calibration and alignment checks. They will be performed on an annual basis or as required by system malfunctioning. Alarms are expected as part of these checks.

ELO 1.3	**EXPLAIN the consequences of a failure of the Area Radiation Monitoring System to fulfill its intended purpose, including the effects on other systems or components, overall plant operation, and safety.**
ELO 2.2	**Given a description of abnormal equipment status for the Area Radiation Monitoring System, EXPLAIN the significance of the condition on system operation.**
ELO 2.3	**Given a description of the Area Radiation Monitoring System equipment status, STATE any corrective actions required to return system operation to a normal condition.**

Abnormal Operations

If routine surveillance and/or testing reveals defective or inoperable equipment, Maintenance should be notified immediately. RCO will need to perform monitoring with portable radiation detectors on a periodic basis until the equipment can be repaired or replaced.

High Radiation Alarm

If a high radiation alarm occurs (audible and/or a red flashing light are on), affected personnel will cease work activities and exit the alarmed area, other personnel in CIF will be notified, and RCO personnel will be notified. After RCO personnel have assessed the area, supervision will be notified of the area conditions and restrictions.

Causes of high radiation alarms are either radiation sources or improper operation of the detector. Until proven otherwise, all alarms will be treated as an actual high radiation condition. Possible events which could cause high radiation to be present at a detector are large releases of contaminated material, radiation sources positioned near the detector, and build up of contamination in process systems leading to a rise in background radiation.

When returning to an area with a high radiation alarm condition, operators should be alert to potential causes. RCO personnel will assist in conducting searches for radiation sources, but in the event that the high radiation alarm is due to a release of contamination, operator knowledge will be required to locate and isolated potential leaks. For a radiation alarm in the Ashcrete Area, the Continuous Air Monitor (CAM) for that area should be checked. A rise in the background radiation will cause a resultant rise in the background sensed by the Air Monitoring detector, but a significant rise in the counts from the CAM detector may confirm a release or airborne contamination problem.

High radiation alarms caused by the slow build up of contamination in the systems should be avoided by sufficient response to the rising levels.

High Radiation Alarms do not normally indicate life or health threatening conditions. The alarm setpoints are typically set high enough above background levels to avoid spurious alarms, but are low enough to alert operators of significant changes.

Example

Assume that radiation in the Box Handling Area at the truck unloading dock is normally 1.0 mR/hr. Assume that an operator is required to work for six (6) hours to unload a truck of solid waste.

What would the total received dose be for this scenario? What would the total received dose be for a different worker was required to unload the truck with the radiation level at the typical alarm setpoint? How do these doses compare to the SRS Administrative Control Level for whole body dose received for a month?

A worker in a 1.0 mR/hr radiation area for twelve hours will receive:

$$\frac{1.0 \text{ mR}}{\text{hr}} \left| \, 6 \text{ hours} \right. = \underline{6.0 \text{ mR}}$$

For a background level of 1.0 mR/hr the alarm setpoint (from Table 3) is typically 2.0 mR/hr above background. For 1.0 mR/hr background, the typical setpoint will be 3.0 mR/hr. Therefore, this operator in the slightly higher radiation area with a radiation level at the alarm setpoint would receive:

$$\frac{3.0 \text{ mR}}{\text{hr}} \left| \, 6 \text{ hours} \right. = \underline{18.0 \text{ mR}}$$

The SRS Administrative Control Level for whole body dose received for a month is 100 mR. Although the second dose is three times the first, both are well below the control levels. Repeated exposure to either dose rate would eventually lead to exceeding the control level, but neither level is life threatening.

It should be noted that these cases are for example purposes only. Workers would be expected to be aware of typical exposure levels in the areas where they work. All operators should use the principles of time distance and shielding to minimize their exposure.

Monitor Failure Alarm

If the amber light illuminates, a gamma radiation signal lower than the background is indicated. This is indicative of a monitor failure. If the "AB" toggle switch is in the "AB" position, and other conditions are normal, the detector should be repaired or replaced by Maintenance.

Possible causes of a monitor failure could involve the power supply to the readout/control module, failure of the internal LED, or malfunctioning detector or monitor. If the detector is operating properly, and the background level at the detector is high enough, a failure of the LED will not cause a monitor failure.

In the case where a detector in not operating properly, RCO will be required to survey the affected area more frequently to track any changes in radiation levels. Other measures which may be implemented may include either not receiving or transferring waste or continuous monitoring by RCO while receiving waste. This would allow for the detection of unusually high radiation sources entering the facility. The build up of contamination in the ashcrete process area should be